REVIEW

A Systematic Review of Principal Component Analysis–Derived Dietary Patterns in Japanese Adults: Are Major Dietary Patterns Reproducible Within a Country?

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ABSTRACT

Principal component analysis (PCA) has been widely used in nutritional epidemiology to derive dietary patterns. However, although PCA-derived dietary patterns are population-dependent, their reproducibility in different populations is largely unexplored. We aimed to investigate whether major dietary patterns are consistently identified among different populations within a country and, if so, how similar these dietary patterns are. We conducted a systematic review of PCA-derived dietary patterns in Japanese adults using PubMed and Web of Science for English articles and Ichushi-Web and CiNii databases for Japanese articles. We assessed the reproducibility of major dietary patterns using congruence coefficients (CCs), with values ≥0.80 considered to represent fair similarity. From 65 articles (80 studies) included in this review, 285 different dietary patterns were identified. Based on the names of these patterns, major dietary patterns were Western ($n = 34$), Japanese ($n = 12$), traditional ($n = 10$), traditional Japanese ($n = 9$), healthy ($n = 18$), and prudent ($n = 9$) patterns. When assessment was limited to high-quality data (i.e., studies based on a sample size ≥200 and use of a validated dietary assessment questionnaire or multiple-day dietary record), the median CC was low for Western (0.44), traditional (0.59), and traditional Japanese (0.31) patterns. Conversely, the median CC was 0.89 for healthy, 0.86 for prudent, and 0.80 for Japanese patterns; and the proportion of pairs with a CC ≥0.80 was 87.3%, 64.3%, and 50.0%, respectively. Characteristics shared among these 3 dietary patterns included higher intakes of mushrooms, seaweeds, vegetables, potatoes, fruits, pulses, and pickles. In conclusion, this systematic review showed that some of the major dietary patterns are relatively reproducible in different populations within a country, whereas others are not. This highlights the importance of careful interpretation of PCA-derived dietary patterns. Our findings in Japan should be confirmed in different countries and globally. This study was registered at https://www.crd.york.ac.uk/prospero/ as CRD42018087669. *Adv Nutr* 2019;10:237–249.

Keywords: dietary pattern, food consumption pattern, principal component analysis, factor analysis, congruence coefficient, reproducibility, similarity

Introduction

Because it is not possible to investigate the potential synergistic effects of foods and nutrients using the traditional single food and nutrient approach, nutritional epidemiology has recently made a major shift to the assessment of dietary patterns (1). There are 2 main approaches to derive dietary patterns: the a priori (hypothesis-derived) and a posteriori (data-derived) approaches. The a posteriori approach is suitable for describing a representative picture of the variation in diet in a specific population and has been applied in many studies (2, 3). For these analyses, the most commonly used method is principal component analysis (PCA), a data-reduction method based on correlation or covariance matrices of the original variables that produces a set of values for linearly uncorrelated variables (components, factors, or patterns).

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One of the major criticisms of PCA-derived dietary patterns is that the dietary patterns obtained are population-dependent and may not be reproducible in other populations, limiting generalizability (4–6). In fact, although the reproducibility of PCA-derived dietary patterns in the same population has been investigated, using different dietary assessment methods or at different time points (7–12), reproducibility in different populations has been largely overlooked (13, 14). Several researchers have acknowledged in their systematic reviews and meta-analyses that PCA-derived dietary patterns are not easily comparable between different study populations despite the use of similar labels by the original authors (15–20). Nevertheless, these dietary patterns have been summarized without substantial reservations (15, 16) or, at most, according to dietary patterns with similar characteristics subjectively considered by review authors (17–20). Systematic evaluation on the reproducibility of major dietary patterns in different populations would provide important insights into the possible generalizability of dietary pattern studies.

Partly due to the low prevalence of coronary artery disease and long life expectancy of Japanese, Japanese dietary habits have long attracted the interest of researchers from other countries (21, 22). The Japanese diet typically includes high intakes of refined grains (mainly white rice), seaweeds, vegetables, fish, soybean products, and green tea and low intakes of whole grains, processed meat, nuts, and soft drinks (23, 24). Although many Japanese studies have applied PCA to derive dietary patterns, we are unaware of any systematic assessment of PCA-derived dietary patterns in different populations within a country in terms of similarity or reproducibility. If available, this kind of information would be helpful in the development of country-specific, food-based dietary guidelines.

Therefore, we conducted a systematic review of PCA-derived dietary patterns in free-living Japanese adults consuming a self-selected diet. We aimed to investigate whether major dietary patterns are consistently identified among different populations within a country and the degree of reproducibility of these dietary patterns.

Methods

The review protocol was registered in the Prospective Register of Systematic Reviews database (registration no: CRD42018087669). This systematic review was planned by 1 of the authors (KM) with the support of another author (SS) and conducted according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (25, 26), as described below.

Eligibility criteria

Articles were eligible for inclusion if they *1*) were full-text articles in peer-reviewed journals, *2*) identified overall dietary patterns based on food intake using PCA (or factor analysis with a principal component procedure), and *3*) enrolled community-dwelling adults (aged $\geq$18 y) living in Japan. Articles were excluded if they *1*) were reviews, conference reports, or abstracts; *2*) identified dietary patterns using PCA based exclusively on nutrient intake, nutritional biomarkers, or dietary behaviors or using cluster analysis or other methods of an a priori nature (including reduced rank regression and diet scores) or patterns of meals (rather than overall diet); or *3*) focused only on a group of individuals who are different from the general population, including individuals with an illness (e.g., patients with diabetes), institutionalized individuals, pregnant or breastfeeding women, athletes, and individuals consuming special diets (e.g., vegetarians). No restriction on study design was imposed; data derived from healthy control subjects in case-control studies or baseline or run-in period data in experimental studies were considered eligible if all the eligibility criteria were met. Year of publication was not limited, but only articles written in English or Japanese were considered.

Search strategy

An electronic literature search was conducted by 1 of the authors (KM) on 5 February 2018 using PubMed (1966–present) and Web of Science Core Collection (1900–present) for English articles and Ichushi-Web (1977–present) and CiNii (1970–present) databases for Japanese articles. The following search string was used: ("dietary pattern" OR "diet pattern" OR "food pattern" OR "food intake pattern" OR "food consumption pattern" OR "eating pattern" OR "dietary quality" OR "diet quality" OR "dietary patterns" OR "diet patterns" OR "food patterns" OR "food intake patterns" OR "food consumption patterns" OR "eating patterns" OR "dietary qualities" OR "diet qualities") AND (factor OR component OR cluster OR score OR factors OR components OR clusters OR scores) AND (japan OR japanese).

Study selection

Titles and abstracts of all articles retrieved in the electronic search were screened for eligibility by 1 of the authors (KM). This screening was independently duplicated by a review team consisting of 6 authors (NS, AF, XY, AH, HF, and H-CW). Any disagreements were discussed and resolved by consensus or by another author (SS), if necessary. After duplicate articles were removed, the full texts of screened articles were retrieved. The reference lists of the articles identified during this process were also examined by hand search (by KM) to further identify potentially relevant articles. The full-text articles were then independently evaluated by 1 of the authors (KM) and by the review team (NS, AF, XY, AH, HF, and H-CW).

Data collection

Using a standardized, prepiloted form, data extraction was performed by 1 of the authors (KM) and checked by the review team (NS, AF, XY, AH, HF, and H-CW). Information extracted from each study included the following: author names, publication year, study year, characteristics of participants (sex, age, and sample size), dietary assessment method (including information on validity, number of days, and whether overall diet was assessed), rationales and procedures used to derive dietary patterns, number of foods considered in dietary pattern analysis (in addition to whether variables other than food intake were considered) and the unit of input variables, number of factors derived and variance explained, name of factors, naming strategy, foods with high ($\geq$0.30 or ≤ -0.30) factor loadings, and for major dietary patterns (as described below), all factor loading values reported. When >1 article reported dietary patterns based on the same dietary assessment method in (almost) the same population (e.g., 2 separate articles on prospective cohort studies investigating associations of dietary patterns with diabetes and cardiovascular disease in the same population), data were extracted from the article reporting the most comprehensive information. When men and women were analyzed separately in 1 article, these analyses were treated separately (even when data from a sex-combined analysis were reported).

Assessment of risk of bias and study quality

Risk of bias and study quality were assessed by 1 of the authors (KM) for each study on the basis of dietary assessment method and sample size. These items were selected from a scoring system developed by Voortman et al. (27). For the former, we considered sufficient studies in which actual dietary intake was estimated by dietary record or recall over multiple days, or dietary intake was assessed using a validated dietary assessment questionnaire. For the latter, we considered studies based on $\geq$200 participants to be sufficient. This (arbitrary) criterion was determined considering the sample size in previous methodologic studies [i.e., n = 111 (7) and 127 (8)], in which meaningful dietary patterns were identified using dietary information from a validated dietary assessment questionnaire and multiple-day dietary record in a homogeneous population. Studies classified sufficient for both items were considered to report high-quality data.

Synthesis of results

We first conducted a narrative synthesis of the findings from the included studies in terms of population characteristics, dietary assessment method, dietary pattern analysis, and study quality. Second, we investigated whether a number of similar dietary patterns were repeatedly identified in different studies by considering the subjective names of dietary patterns. Then, we assessed the reproducibility of major dietary patterns using congruence coefficients (CCs) between the factor loadings from each study. The CC (ranging from -1 to 1) is the preferred index for measuring the component or factor similarity extracted from PCA or factor analysis (28). A number of researchers have argued that a CC $\geq$0.80 is sufficient to assume that the components have a fair similarity (29, 30), whereas others maintain that a more conservative approach is required and set the cutoff point as 0.85 (31). Given the diverse populations and PCA procedures used in studies that report dietary patterns, we considered that a CC $\geq$0.80 would be sufficient to assume fair similarity between components.

We calculated the CC between the factor loadings of a particular pattern from 1 study (l_{1f}) with the factor loadings of a particular pattern from another study (l_{2f}) for each of the $f = 1, \ldots, 23$ food groups as follows:

$$\mathrm{CC} = \frac{\sum_{f=1}^{23} l_{1f} \times l_{2f}}{\sqrt[2]{\left(\sum_{f=1}^{23} l_{1f}^2\right) \times \left(\sum_{f=1}^{23} l_{2f}^2\right)}} \tag{1}$$

For this purpose, food items appearing in each study were categorized into 23 food groups (**Supplemental Table 1**). Grouping of foods was done a priori on the basis of similarities in nutrient profile or culinary use of the foods, mainly in accordance with the Standard Tables of Food Composition in Japan (32) and the Japanese National Health and Nutrition Survey's classification of food groups (24). When low factor loading values (e.g., > -0.20 to <0.20) were not reported (for simplicity), a factor loading value of 0 was assigned. When multiple food items were available for 1 food group, we calculated the mean value of factor loadings and assigned this value. When no food item was available in a food group, we excluded the food group for the calculation of CCs. The CCs were calculated for each pair of factor loadings in each of the major dietary patterns identified, and median and 25th and 75th percentiles of CCs as well as the number and percentage of CCs $\geq$0.80 for each of the major dietary patterns are shown as summary statistics. These analyses were first conducted based on all data and then using high-quality data only (determined based on sample size and dietary assessment method, as mentioned above). All data management and analyses were performed by 1 of the authors (KM) using Microsoft Excel 2016 MSO and SAS statistical software (version 9.4; SAS Institute).

Results

Figure 1 shows a flow diagram of the study selection process. Our electronic literature search identified 1095 records (including duplicates). After excluding 964 records by title/abstract screening, 144 full-text articles (including 13 articles identified by hand search) were assessed in detail. The number of articles considered eligible was 90. After excluding articles that reported dietary patterns based on the same dietary assessment method in (almost) the same population, 65 articles (41 English articles and 24 Japanese articles) (9, 10, 33–95) were included in this systematic review, representing 80 studies.

Study characteristics

Basic characteristics of the 80 studies were summarized (**Table 1** for studies identifying major dietary patterns, **Supplemental Table 2** for studies not identifying major dietary patterns). Although the first study that met the inclusion criteria was published ~40 y ago (in 1979), the majority of studies (n = 48; 60%) were published after 2010. More than half of the studies (n = 43; 54%) were conducted in both sexes combined, and the mean and range of participant age varied. Sample size ranged from 59 to 54,222 (median:

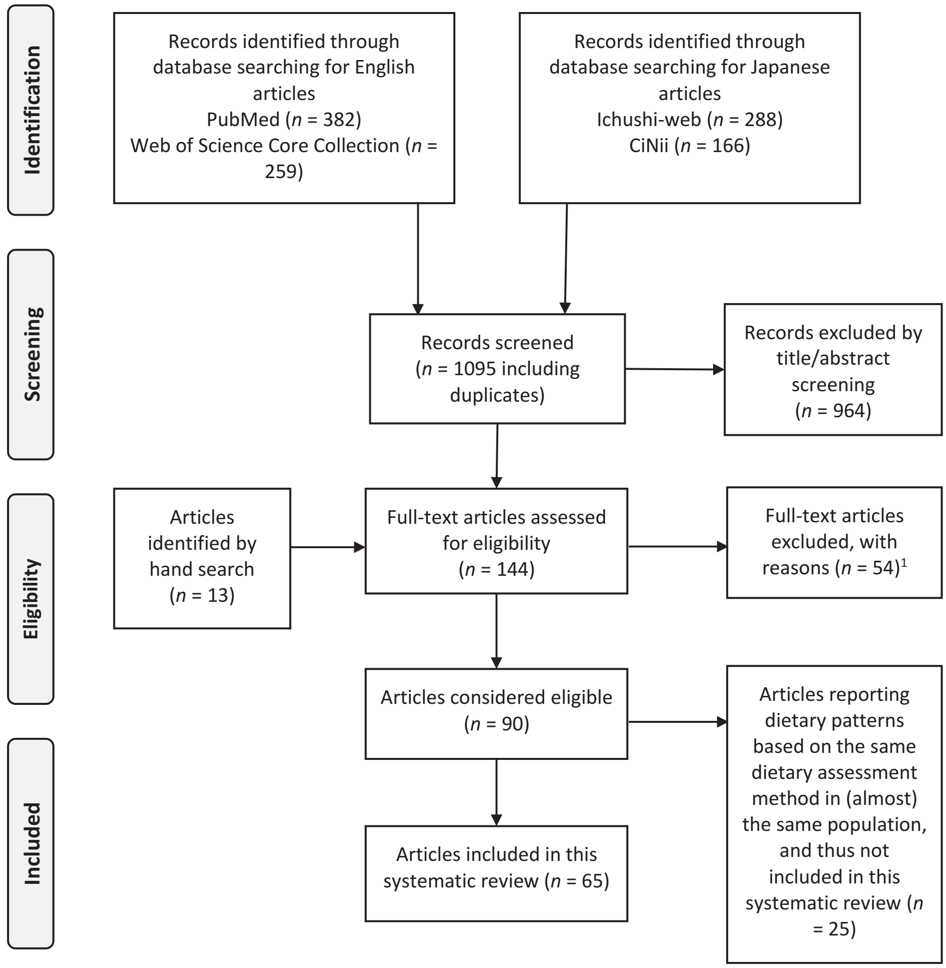

FIGURE 1 Flow diagram of the study selection process. [1]Reasons for exclusion were as follows: cluster analysis ($n = 5$), no dietary pattern analysis ($n = 15$), factor loading values not available ($n = 5$), participants from other countries ($n = 5$), patients ($n = 7$), vegetarians ($n = 1$), no intake data ($n = 1$), food combination ($n = 1$), ecological study ($n = 1$), household survey ($n = 6$), far from the general population (survivors of the Great East Japan Earthquake; $n = 1$), journal not peer reviewed ($n = 2$), and multiple dietary data collected from the same person into principal component analysis without considering the multiple nature of dietary data ($n = 4$).

517), with 19 studies (24%) based on <200 participants. In terms of dietary assessment method, a validated dietary assessment questionnaire was used in more than half ($n = 43$; 54%) of studies (mainly recent studies), whereas multiple-day diet records were used in 24% ($n = 19$) of studies, most of which were older studies. Other studies used a nonvalidated diet questionnaire ($n = 15$) or a 1-d diet record ($n = 2$).

Dietary pattern analysis strategy

To determine the number of factors in PCA, ≥1 of the following criteria was used in 59 (74%) studies: eigenvalue (generally a 1.0 cutoff), scree plot, and interpretability of the factors (**Supplemental Table 3**). PCA was conducted by using the correlation matrix of food intake variables in all studies. Varimax rotation was preferred to Promax rotation (53 compared with 6 studies). The number of food items included in PCA ranged from 7 to 52 (median: 30). The majority of studies ($n = 49$; 61%) assessed the whole diet; others did not consider at least some part of diet, such as alcoholic beverages and staple foods (i.e., rice, bread, and noodles), whereas 2 studies were based on only a limited number of aggregated food items. Log-transformed food intake variables were used in 12 studies (15%), whereas energy-adjusted food intake variables were used in 24 studies (30%). Naming of factors was conducted based on food items with high factor loadings in 51 studies (64%), whereas somewhat objective cutoff values were used in 2 studies (e.g., foods with factor loadings >0.30 or < −0.30).

Major dietary patterns

The number of dietary patterns derived in each study ranged from 2 to 9 (median: 3). In total, 285 different dietary patterns (including 50 patterns without any name) were derived in 80 studies (**Supplemental Table 4**). On the basis of the names of these patterns, the major dietary patterns were as follows (Table 1): Western ($n = 34$), Japanese ($n = 12$),

TABLE 1 Basic characteristics of studies eligible for this systematic review on principal component analysis–derived dietary patterns in Japanese adults (studies identifying major dietary patterns)[1]

First author, publication year (ref)	Study year	Sex; age (range, mean, or both), y	Sample size, *n*	Dietary assessment method	No. of dietary patterns derived	Major dietary patterns identified	Study no.
Moriguchi, 1980 (35)	1976–1979	M/F; 20–70	774 (M: 366; F: 408)	1-d DR	6	TRD	3
Toyokawa, 1981 (36)	1980	F; 30–69	225	3-d DR	9	WTN	4
Ikeda, 1982 (37)	1980	M/F; ≥20	290 (M: 40; F: 250)	3-d DR	7	WTN	5
Nagayama, 1995 (47)	1978–1980	F; 47.0	116	3-d DR	7	WTN	15
Chi, 2003 (52)	2001	M/F; 40–79 (63)	1308 (M: 463; F: 845)	FFQ (not validated)	3	PRD, WTN	20
Kim, 2004 (54)	1990	M; 40–59	20,300	FFQ (validated)	3	HLH, TRD, WTN	22a
		F; 40–59	21,812	FFQ (validated)	3	HLH, TRD, WTN	22b
Mizoue, 2005 (55)	1999–2002	M; 52.4	1341	FFQ (partly validated)	3	JPN	23
Okubo, 2006 (56)	2000–2003	F; 40–55 (46.4)	291	DHQ (validated)	4	HLH, TRDJ, WTN	24
Okubo, 2007 (57)	2005	F; 18–20 (18.1)	3770	DHQ (validated)	4	HLH, TRDJ, WTN	25
Shimazu, 2007 (58)	1994	M/F; 40–79	40,547	FFQ (validated)	3	JPN	26
Nanri, 2008 (59)	2004–2006	M/F; 50–74	7802 (M: 3276; F: 4526)	FFQ (partly validated)	4	HLH, WTN	27
Sadakane, 2008 (60)	1992–1995	M/F; 40–69 (M: 56.3; F: 56.6)	8057 (M: 3148; F: 4909)	FFQ (partly validated)	3	WTN	28
Kurotani, 2010 (61)	2000–2003	M/F; M: 60.1; F: 60.5	775 (M: 485; F: 290)	FFQ (validated)	3	PRD	29
Monma, 2010 (62)	2002	M/F; ≥70	877	FFQ (validated)	3	TRDJ	30
Nanri, 2010 (63)	2006	M/F; 21–67	521 (M: 309; F: 212)	BDHQ (validated)	3	JPN, WTN	31
Okubo, 2010 (9)	2002–2003	F; 31–69 (49.6)	92	DHQ (validated)	3	HLH, WTN, TRDJ	32a
				16-d DR	3	HLH, TRDJ, WTN	32b
		M; 32–76 (52.8)	92	DHQ (validated)	2	HLH, WTN	32c
				16-d DR	2	HLH, WTN	32d
Arisawa, 2011 (64)	2002–2007	M/F; 15–73 (43.8)[2]	1656 (M: 755; F: 901)[2]	FFQ (not validated)	5	HLH	33
Kumeta, 2011 (66)	2008	M/F; 20–86 (56.3)	763 (M: 288; F: 475)	FFQ (not validated)	5	TRDJ	35
Nanri, 2011 (67)	2005–2007	M; 40–69 (55.7)	3905	FFQ (validated)	5	HLH, WTN	36a
		F; 40–69 (55.1)	5640	FFQ (validated)	5	HLH, WTN	36b

(*Continued*)

TABLE 1 (*Continued*)

First author, publication year (ref)	Study year	Sex; age (range, mean, or both), y	Sample size, *n*	Dietary assessment method	No. of dietary patterns derived	Major dietary patterns identified	Study no.
Ogawa, 2011 (68)	NR	M/F; ≥65 (71.3)	80 (M: 19; F: 61)	BDHQ (validated)	4	JPN, WTN	37
Morimoto, 2012 (69)	1990–1992	M/F; 40–69	5665 (M: 1995; F: 3670)	FFQ (not validated)	3	HLH	38
Nanri, 2012 (10)	1994–1998	M; 40–69	244	FFQ (validated)	3	PRD, WTN, TRD	39a
				28- or 14-d DR	3	PRD, WTN, TRD	39b
		F; 40–69	254	FFQ (validated)	3	PRD, WTN, TRD	39c
				28- or 14-d DR	3	PRD, WTN, TRD	39d
Sugawara, 2012 (70)	2011	M/F; 22–86	791 (M: 303; F: 488)	BDHQ (validated)	4	HLH, WTN	40
Yap, 2012 (71)	NR	M/F; 30–65 (43.0)	136 (M: 94; F: 42)	FFQ (validated)	2	JPN, WTN	41
Konishi, 2013 (73)	2011	F; 20.2	59	3-d DR	4	HLH, JPN, TRD	43
Nanri, 2013 (75)	1995 or 1998	M; 45–74	47,408	FFQ (validated)	3	PRD, WTN, TRD	45a
		F; 45–74	54,222	FFQ (validated)	3	PRD, WTN, TRD	45b
Suzuki, 2013 (76)	NR	M/F; 21–65 (43.4)	2266 (M: 2025; F: 241)	BDHQ (validated)	3	JPN, WTN	46
Arisawa, 2014 (77)	2008–2011	M/F; 35–70	513 (M: 377; F: 136)	FFQ (validated)	4	PRD, WTN	47
Tomata, 2014 (79)	2006	M/F; ≥65 (73.9)	14,260	FFQ (validated)	3	JPN	49
Kashino, 2015 (80)	2009	M/F; 20–65	509 (M: 296; F: 213)	BDHQ (validated)	3	JPN, WTN	50
Kurotani, 2015 (81)	2012–2013	M/F; 18–70	2108 (M: 1883; F: 225)	BDHQ (validated)	3	HLH, WTN, TRDJ	51
Satake, 2015 (82)	2013	M/F; 54	993 (M: 382; F: 611)	BDHQ (validated)	3	HLH, WTN	52
Fujii, 2016 (85)	2013	M/F; 18–63 (20.2)	240 (M: 61; F: 179)	FFQ (not validated)	3	JPN, WTN	55
Nanri, 2016 (88)	2005–2008	M/F; 35–69	1720 (M: 955; F: 765)	FFQ (validated)	4	HLH, WTN	58
Niu, 2016 (89)	2008	M; ∼43	735	BDHQ (validated)	3	JPN	59a
		F; ∼42	245	BDHQ (validated)	3	JPN	59b
Htun, 2017 (91)	2012	M/F; 20–84	11,365 (M: 4686; F: 6679)	1-d DR	3	TRDJ, WTN	61
Osawa, 2017 (95)	NR	M/F; 87.8	512 (M: 224; F: 288)	BDHQ (validated)	2	TRDJ	65

[1] Articles are sorted by publication year followed by alphabetical order of the first author. BDHQ, brief diet history questionnaire; DHQ, diet history questionnaire; DR, dietary record; HLH, healthy; JPN, Japanese; NR, not reported; PRD, prudent; ref, reference; TRD, traditional; TRDJ, traditional Japanese; WTN, Western.
[2] Including 62 individuals aged 15–19 y.

traditional (n = 10), traditional Japanese (n = 9), healthy (n = 18), and prudent (n = 9) patterns (for each of these patterns, factor loading values of the selected 23 food groups calculated on the basis of original factor loadings in each of the studies are shown in **Supplemental Tables 5–10**, respectively). Considering the median factor loading values of the 23 food groups (**Table 2**), the Western pattern was characterized by higher intakes of fats, oils, bread, meat, and seasonings, whereas the Japanese pattern was characterized by higher intakes of mushrooms, seaweeds, potatoes, vegetables, pickles, pulses, seasonings, fruits, and fish and shellfish. The traditional pattern was characterized by a higher intake of pickles only, whereas the traditional Japanese pattern was characterized by higher intakes of rice and pulses and a lower intake of bread. Both the healthy and prudent patterns were characterized by higher intakes of mushrooms, seaweeds, vegetables, potatoes, fruits, and pulses. When only high-quality data were assessed (after excluding studies with a sample size <200 or use of a nonvalidated diet questionnaire or 1-d dietary record), similar characteristics were observed, with some exceptions (no contribution of fats to the Western pattern, no contribution of seasonings to the Japanese pattern, a lower fat intake as a characteristic of traditional pattern, and a higher intake of pickles as a characteristic of the healthy pattern).

Reproducibility of major dietary patterns

We assessed reproducibility of these major dietary patterns by calculating the CC for each pair of the same dietary patterns. When all data were used, the median values of CCs ranged from 0.41 (traditional pattern) to 0.81 (healthy and prudent patterns) (**Table 3**). Based on high-quality data only, the median CCs were still low for the Western (0.44), traditional (0.59), and traditional Japanese (0.31) patterns. Conversely, those for the Japanese (0.80), healthy (0.89), and prudent (0.86) patterns were $\geq$0.80 and the proportion of pairs with a CC $\geq$0.80 was 50.0%, 87.3%, and 64.3%, respectively.

Because of the apparent similarity of the healthy, prudent, and Japanese patterns, at least with regard to median factor loading values, we further calculated CCs between these dietary patterns. For the healthy and prudent patterns (based on high-quality data), the median CC was 0.84 and the percentage of pairs with a CC $\geq$0.80 was 69.3% (**Table 4**). The corresponding values were 0.85 and 78.4% for the Japanese and healthy patterns and 0.82 and 59.4% for the Japanese and prudent patterns.

Discussion

In this systematic review of 80 dietary pattern studies in Japan, we identified 6 major dietary patterns: Western, Japanese, traditional, traditional Japanese, healthy, and prudent patterns. However, characteristics of the Western, traditional, and traditional Japanese patterns varied considerably across studies and their reproducibility as assessed by CCs was low. In contrast, the Japanese, healthy, and prudent patterns appeared to have a number of characteristics in common, such as higher intakes of mushrooms, seaweeds, vegetables, potatoes, fruits, pulses, and pickles. Moreover, these patterns were somewhat reproducible across studies. To our knowledge, this is the first systematic review to identify major dietary patterns within a country and to assess their reproducibility using CCs.

In previous studies, the healthy and prudent patterns were characterized by high intakes of fruits, vegetables (including mushrooms), poultry, fish, low-fat dairy, legumes, and whole grains (18, 19, 96, 97). The healthy and prudent patterns observed here (characterized by high intakes of mushrooms, seaweeds, vegetables, potatoes, fruits, and pulses) were generally similar, but several additional features warrant mention. One was a high intake of seaweeds and potatoes, which has been observed in the Korean dietary pattern (98, 99) and is probably due to the fact that these foods are frequently cooked or consumed with vegetables in East Asian countries. Furthermore, high intakes of whole grains and low-fat dairy were not characteristics of these dietary patterns, mainly because intakes of these foods are generally very low in Japan (100). Another interesting feature was the lack of any apparent contribution of poultry (chicken) to these patterns, which is at variance with results from other East Asian countries such as Korea (98, 99) and China (101). These may be unique characteristics of healthy or prudent patterns in Japan, and should be considered, for example, in the development of food-based dietary guidelines or recommendations.

The Japanese pattern (characterized by higher intakes of mushrooms, seaweeds, potatoes, vegetables, pickles, pulses, seasonings, fruits, and fish and shellfish) had many characteristics in common with the healthy and prudent patterns. Because the term "Japanese" is rather qualitative (as mentioned below), the naming is clearly misleading, because it at least partly reflects researchers' perception that the Japanese diet is healthy (102–104). Accordingly, this pattern should more likely have been labeled as a healthy or prudent pattern.

The healthy, prudent, and Japanese dietary patterns were similar in terms of factor loading values but reproducibility within and between them (as assessed by CCs) was also considerably high. This is generally consistent with a series of studies conducted by 1 research group, which found that major dietary patterns in different samples extracted from similar populations were fairly reproducible (13, 14). In addition, this finding does not conflict with previous perceptions that healthy and prudent patterns are interchangeable (18, 19, 96, 97), although it might be better to consistently use either of the terms (healthy or prudent) in future research. It would be of interest to investigate if the present findings in Japan would also be observed in different countries or globally.

Although previous studies have generally characterized the Western dietary pattern by high intakes of red meat, processed meat, refined grains, sweets, sugary drinks, eggs, potatoes, high-fat dairy products, and fried foods (18, 19, 96, 97), the Western pattern observed was, on average, characterized by higher intakes of fats, oils, bread, meat,

TABLE 2 Factor loadings for major dietary patterns in Japanese adults[1]

	Western		Japanese		Traditional		Traditional Japanese		Healthy		Prudent	
	All data[2]	High-quality data only[3]	All data[2]	High-quality data only[3]	All data[2]	High-quality data only[3]	All data[2]	High-quality data only[3]	All data[2]	High-quality data only[3]	All data[2]	High-quality data only[3]
No. of studies	34	24	12	8	10	8	9	5	18	11	9	8
Rice	−0.26	−0.26	0.00	0.00	0.22	0.22	0.60*	0.64*	0.00	0.00	0.00	0.00
Bread	0.35*	0.34*	0.00	0.00	−0.15	−0.15	−0.39*	−0.43*	0.00	0.00	0.00	0.00
Noodles	0.08	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Potatoes	0.00	0.00	0.56*	0.53*	0.00	0.00	0.18	0.22	0.51*	0.55*	0.57*	0.57*
Pulses	0.00	0.00	0.36*	0.36*	0.00	0.00	0.38*	0.37*	0.39*	0.39*	0.59*	0.51*
Nuts	0.00	0.00	0.00	0.00	0.22	0.22	0.00	0.00	0.11	0.00	0.27	0.27
Fruits	0.00	0.00	0.31*	0.28	0.20	0.26	0.13	0.00	0.49*	0.42*	0.55*	0.54*
Mushrooms	0.00	0.00	0.67*	0.63*	0.00	0.10	0.00	0.00	0.61*	0.62*	0.58*	0.58*
Seaweeds	0.00	0.00	0.59*	0.57*	0.00	0.00	0.26	0.20	0.56*	0.55*	0.61*	0.61*
Vegetables	0.06	0.03	0.56*	0.56*	0.02	0.02	0.17	0.01	0.59*	0.59*	0.60*	0.62*
Pickles	−0.15	−0.17	0.43*	0.41*	0.60*	0.60*	0.24	0.09	0.25	0.30*	0.27	0.27
Meat	0.35*	0.35*	0.04	0.05	0.09	0.09	−0.01	0.00	0.00	0.00	0.09	0.07
Fish and shellfish	0.00	0.00	0.30*	0.30*	0.29	0.29	0.15	0.00	0.23	0.17	0.24	0.24
Eggs	0.21	0.01	0.24	0.24	0.03	0.06	0.02	0.00	0.02	0.00	0.27	0.27
Dairy products	0.16	0.17	0.00	0.04	0.05	0.05	0.00	0.00	0.17	0.12	0.23	0.23
Confectioneries	0.19	0.18	0.00	0.08	0.15	0.28	−0.05	−0.15	0.00	0.00	0.14	0.22
Fats	0.39*	0.19	0.00	−0.04	−0.10	−0.42*	0.00	0.00	0.00	0.00	0.00	−0.07
Oils	0.39*	0.31*	0.12	0.20	0.15	0.05	−0.01	0.00	0.14	0.08	0.17	0.21
Seasonings	0.30*	0.41*	0.34*	0.12	0.00	0.00	0.08	0.06	0.16	0.00	0.16	0.18
Soups	0.00	0.00	0.24	0.06	0.10	0.10	0.27	0.24	0.07	0.00	0.04	0.00
Alcoholic beverages	0.00	0.00	−0.03	−0.03	0.07	0.07	0.00	0.00	−0.08	0.00	−0.01	−0.01
Nonalcoholic and caloric beverages	0.17	0.17	0.00	0.00	0.00	0.00	−0.02	0.00	0.00	0.00	0.00	0.00
Nonalcoholic and noncaloric beverages	0.11	0.15	0.08	0.08	0.00	0.00	0.00	0.00	0.03	0.00	0.08	0.08

[1]Values are medians unless otherwise indicated. *Factor loadings with an absolute value ≥0.30.
[2]All relevant studies were included: studies 3–5, 15, 20, 22a, 22b, 23–31, 32a–d, 33, 35, 36a, 36b, 37, 38, 39a–d, 40, 41, 43, 45a, 45b, 46, 47, 49–52, 55, 58, 59a, 59b, 61, and 65 (see Table 1).
[3]Studies with low quality (i.e., sample size <200 or use of a nonvalidated dietary assessment questionnaire or only 1-d dietary data; studies 3, 15, 20, 32a–d, 33, 35, 37, 38, 41, 43, 55, and 61) were excluded (see Table 1).

TABLE 3 Congruence coefficients for major dietary patterns in Japanese adults

	Western		Japanese		Traditional		Traditional Japanese		Healthy		Prudent	
	All data[1]	High-quality data only[2]	All data[1]	High-quality data only[2]	All data[1]	High-quality data only[2]	All data[1]	High-quality data only[2]	All data[1]	High-quality data only[2]	All data[1]	High-quality data only[2]
No. of pairs	561	276	66	28	45	28	36	10	153	55	36	28
Median	0.44	0.44	0.77	0.80	0.41	0.59	0.49	0.31	0.81	0.89	0.81	0.86
25th percentile	0.26	0.26	0.58	0.79	0.15	0.49	0.30	0.09	0.73	0.86	0.71	0.78
75th percentile	0.59	0.61	0.81	0.89	0.63	0.67	0.62	0.55	0.89	0.91	0.91	0.91
≥0.8												
n	15	13	21	14	4	4	1	1	84	48	18	18
%	2.7	4.7	31.8	50.0	8.9	14.3	2.8	10.0	54.9	87.3	50.0	64.3

[1]All relevant studies were included: studies 3–5, 15, 20, 22a, 22b, 23–31, 32a–d, 33, 35, 36a, 36b, 37, 38, 39a–d, 40, 41, 43, 45a, 45b, 46, 47, 49–52, 55, 58, 59a, 59b, 61, and 65 (see Table 1).
[2]Studies with low quality (i.e., sample size <200 or use of a nonvalidated dietary assessment questionnaire or only 1-d dietary data; studies 3, 15, 20, 32a–d, 33, 35, 37, 38, 41, 43, 55, and 61) were excluded (see Table 1).

and seasonings. Thus, the Western pattern in Japan seems to reflect only a part of the globally observed Western pattern, and researchers should be careful not to assume that a Western pattern is similar across different countries. In addition, the reproducibility of the Western pattern was poor, suggesting that this pattern varies considerably across populations in Japan. The same was observed for both the traditional (characterized by a high intake of pickles) and traditional Japanese (characterized by high intakes of rice and pulses and a low intake of bread) patterns. This may be primarily due to the use of such terms. The terms "Western," "traditional," and "traditional Japanese" (and "Japanese") are rather qualitative and provide little or no information about the food or nutrient composition of the patterns. It would therefore be preferable if patterns were named more quantitatively (3).

Interestingly, unlike the general perception that rice is a major feature of diets in Japan (102–104), this food group did not contribute to any of the major dietary patterns perceived as somewhat healthy (i.e., healthy, prudent, and Japanese patterns) but rather only to the traditional Japanese pattern. This may be due to the high intake of rice by many people in Japan (24), which, compared with other foods, does not allow individual diets to be discriminated from each other in terms of healthfulness. In addition, other staple foods (i.e., bread and noodles) also failed to contribute to these somewhat healthy dietary patterns. These findings raise the important question of how the food-based dietary guidelines in Japan should treat these food groups.

The primary strengths of our present review are its inclusion of articles in both the English and Japanese languages, its investigation of PCA-derived dietary patterns in Japan, and its assessment of the reproducibility of patterns using CCs. Our results serve as both a reference and an indication for further research, as well as for the development of food-based dietary guidelines. Among other strengths, the review also benefited from a comprehensive search strategy and the use of 2 independent literature searches.

However, there are several limitations of this review. First, despite our use of wide search terms, search in several relevant databases, and hand-search of reference lists, it is possible that we did not capture all relevant publications. Second, when we regrouped the food items into 23 food groups to calculate CCs for major dietary patterns, we had to subjectively decide the number and classification of these food groups. Thus, it is possible that a different number and classification of food groups might have resulted in somewhat different results. In additon, when a factor loading value for a given food item was not reported in individual studies (for simplicity), the value of 0 was assumed, and when no food item was available for a food group we created, this food group was not considered in the calculation of CCs. Both of these procedures likely contributed to the overestimation of reproducibility. Third, the 3 dietary patterns that showed fair reproducibility (based on high-quality data) were derived from a rather limited number of publications (n = 9 for healthy, 4 for prudent, and 7 for Japanese patterns) or

TABLE 4 Congruence coefficients for healthy and prudent patterns, Japanese and healthy patterns, and Japanese and prudent patterns in Japanese adults

	Healthy vs. prudent		Japanese vs. healthy		Japanese vs. prudent	
	All data[1]	High-quality data only[2]	All data[1]	High-quality data only[2]	All data[1]	High-quality data only[2]
No. of pairs	162	88	216	88	108	64
Median	0.80	0.84	0.77	0.85	0.74	0.82
25th percentile	0.70	0.79	0.58	0.81	0.60	0.73
75th percentile	0.86	0.88	0.86	0.89	0.84	0.87
≥0.8						
n	81	61	96	69	43	38
%	50.0	69.3	44.4	78.4	39.8	59.4

[1] All relevant studies were included: studies 20, 22a, 22b, 23–27, 29, 31, 32a–d, 33, 36a, 36b, 37, 38, 39a–d, 40, 41, 43, 45a, 45b, 46, 47, 49–52, 55, 58, 59a, and 59b (see Table 1).
[2] Studies with low quality (i.e., sample size <200 or use of a nonvalidated dietary assessment questionnaire or only 1-d dietary data; studies 20, 32a–d, 33, 37, 38, 41, 43, and 55) were excluded (see Table 1).

research groups (n = 4 for healthy, 3 for prudent, and 4 for Japanese patterns), which may also have contributed to the overestimation of reproducibility. Nevertheless, these factors should not explain the different findings between the healthy, prudent, and Japanese patterns and the Western, traditional, and traditional Japanese patterns. Fourth, although we considered a CC ≥0.80 as an indication of fair similarity for the assessment of reproducibility, based on several previous studies (29, 30), a more conservative cutoff point (≥0.85) has also been suggested (31). In addition, although we considered that the healthy, prudent, and Japanese patterns were relatively reproducible based on median CCs ≥0.80 (based on high-quality data), when we examined CCs of each of the pairs, at most one-half (not all) of pairs of the healthy, prudent, and Japanese patterns showed values ≥0.80. If the more conservative cutoff point (CC ≥0.85) was applied, only the healthy pattern would be deemed reproducible. Nevertheless, given the diversity of the populations and PCA procedures in dietary pattern studies, we consider that our decision and conclusions are reasonable. Finally, although the present systematic review focused on only PCA, dietary patterns can also be estimated using other a posteriori approaches (e.g., cluster analysis). It would thus be of interest to systematically examine whether dietary patterns derived from other approaches are similar and comparable to PCA-derived dietary patterns, although it is beyond the scope of this review.

In conclusion, this systematic review of 80 dietary pattern studies in Japan identified 6 major dietary patterns: Western, Japanese, traditional, traditional Japanese, healthy, and prudent patterns. However, characteristics of the Western, traditional, and traditional Japanese patterns varied considerably across studies; and reproducibility as assessed by CCs was low. Conversely, the Japanese, healthy, and prudent patterns seemed to have such characteristics in common as higher intakes of mushrooms, seaweeds, vegetables, potatoes, fruits, pulses, and pickles. In addition, these patterns were somewhat reproducible across studies. Thus, this systematic review and quantitative analysis provides empirical evidence that it cannot be assumed that dietary patterns with the same or similar name do not necessarily have the same or similar patterns, at least for some patterns. Consequently, it may be reasonable to consider that the generalizability of findings from previous dietary pattern studies is limited (at least for some dietary patterns). This review also highlights the importance of publication of information on food grouping and factor loadings, in addition to careful naming of patterns, to allow for the assessment of reproducibility or similarity. Whether the present findings are country specific or reproducible in other countries and globally awaits future studies.

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